APPARATUS AND METHOD FOR PRODUCING TOOTH-LIKE PROFILING ON WORKPIECES

The present invention relates to an apparatus according to the preamble of claim 1 as well as a method according the preamble of claim 7.

Impact rolling machines are conventionally used for the cold forming manufacture of cylindrical workpieces which are to be provided with profiled sections having a toothing-like geometry. The movements of the tools, which means the working motion, direction and advancement of the profiling wheels or rollers and the movement of the workpiece, which means the axial advancement to the tools as well as the rotation of the workpiece must be geometrically coordinated with one another in order to achieve the desired profiling with the corresponding dimensions and precision.

The working motion and advancing motion of the tools as well as the workpiece can generally be continuous, which can be realized by the coupling these movements by way of mechanical or electronic drives. However, for the production of a predefined straight or helical toothing, the workpiece should ideally be rotated discontinually or intermittently.

Such a movement can be achieved mechanically, for example by way of a gearbox construction on the basis of the Maltese cross gearing. Such a gearing allows the generation of discontinuous rotation movements starting from a continuously rotating drive apparatus. The respective rotation steps or partitioning steps are thereby dependent on the geometry of the gearing as well as its gear ratio. This means that the partitioning steps to be achieved must be defined and the gearing accordingly developed and constructed on the basis thereof. Such a gearing and thereby also the production installation is generally limited to a preselected workpiece tooth number.

This means that a separate gearing must be constructed practically for each different workpiece tooth number. This represents a relatively high complexity, which last but not least is also reflected in relatively high product cost and high retooling cost.

It is an object of the present invention to find an apparatus, which allows for a simple adjustment of the partitioning steps in the rotation of workpieces, especially for workpieces to be machined with impact rolling machines.

This object is achieved in accordance with the invention by a device with the features according to claim 1. Further preferred embodiments in accordance with the invention result from the features of further claims 2 to 6.

In accordance with the invention, the device for the manufacture of cylindrical workpieces with defined profiling having an axially translatable workpiece holder which is intermittently rotatable about the longitudinal axis as well as forming tools periodically acting on the workpiece, has at least one separate drive for the intermittent rotation of the workpiece holder which is mechanically separate from the drive of the forming tools. This separate drive is connected with an electronic control, which controls the intermittent rotational movement depending on the drive of the forming tools. The rotational position of the workpiece can thereby be advantageously adjusted at will in dependence of the respective movement or position of the forming tools and thereby a precise profile geometry created over the whole length of the profiling of the workpiece. The location as well as the duration of the workpiece standstill during the forming tool contact can thereby be adjusted at will.

For example, a profiling of workpieces can hereby be carried out at a significantly higher rotation speed than with the conventional mechanical connection of the drives. These significantly higher rotations speeds are possible, because the electronically controlled drive compared to the mechanical gearings for the creation of the intermittent rotational movement of the workpiece has a significantly smaller mass inertia. The toothing specific optimal parameters for the geometry of the toothing can thereby also be adjusted significantly quicker. A higher production rate at lower installation cost and production cost is thereby achieved.

The forming tools are preferably profiled wheels or rollers which are driven to continuously revolve along an orbit, whereby the orbit is oriented, preferably adjustably, parallel to or at an angle in relation to the longitudinal axis of the workpiece. The electronic control of the intermittent rotation of the workpiece has proven especially advantageous in particular for the forming processes used on impact rolling machines.

The workpiece holder is preferably supported in a headstock guided and movable in parallel to the workpiece axis and connected with a drive by way of a coupling elastic at least in axial direction. The drive thereby preferably remains free of the forces of the forming tools acting on the workpiece and despite the high forming forces can guarantee

an exact positioning or intermittent rotation. The drive is preferably positioned in a secondary headstock also guided and moveable parallel to the workpiece axis. The secondary headstock can thereby be positioned either in the same guide as the headstock of the workpiece holder or in a separate guide oriented parallel thereto.

Preferably, the periodic movement of the forming tools, the intermittent rotational movement of the workpiece holder, as well as the axial advancement of the workpiece holder have separate drive units which are electronically coupled with one another and preferably connected with the electronic control. A very large potential variability of the movements is thereby achieved and the manufacture of even complicated profile geometries enabled. Such a device is especially suited also for the generation of profilings or toothings which extend obliquely relative to the longitudinal axis.

The workpieces are preferably solid or hollow. The device in accordance with the invention is advantageously suitable for the working of both solid parts as well as hollow parts. Exterior as well as interior profilings or toothings can thereby be produced on hollow parts.

The hollow workpieces are preferably mounted on a cylindrical mandrel, which preferably has a profiled, preferably longitudinally profiled surface.

Furthermore, the object is achieved in accordance with the invention with the features of the method according to claim 7. Preferred embodiments result from the features of the further methods 8 and 9.

In accordance with the invention, the method for the production of cylindrical workpieces having a defined profiling with an axially movable workpiece holder for workpieces, which is intermittently rotatable about the longitudinal axis, as well as forming tools which periodically act on the workpiece, is characterized in that the workpiece is rotated about its longitudinal axis or stopped by way of an electronic control and a drive separate from the forming tools. This is carried out in accordance with the invention in dependence of the movement of the forming tools and thereby for the generation of a predetermined defined profiling geometry.

The control preferably imposes on the workpiece left and right hand rotation as well as a standsill. The desired profiling geometry can thereby be very exactly achieved according to the geometry and movement of the forming tools.

The control preferably also controls the drives and the advancement movement of the forming tools according to preselected settings as well as the axial advancement movement of the workpiece. The whole manufacturing process of the profiling of the cylindrical workpieces can thereby be easily controlled and easily adapted to different workpieces. For example, the respective gearings need not be labour intenstively newly adjusted or converted on the basis of different partitioning numbers for different workpieces.

Furthermore, in accordance with the invention, the use of a device in accordance with the invention and/or the use of the method in accordance with the invention for the manufacture of helical toothings on cylindrical workpieces is claimed.

An exemplary embodiment of the present invention is further described in the following by way of the figures. It shows

Fig. 1 a longitudinal section through a conventional machining apparatus with mechanically coupled gearings;

Fig. 2 a schematic longitudinal section through a device in accordance with the invention with an electronically coupled rotational drive of the workpiece;

Fig. 3 a schematic front view of a workpiece with an engaged forming tool; and

Fig. 4 schematically the longitudinal section through the engagement region of the forming tool on the workpiece according to Fig. 3.

Figure 1 shows a longitudinal section through a conventional impact rolling machine for the machining of cylindrical pieces 1.

The workpiece 1 sits on a workpiece holder 2, which is advanceable along its axis z into the machining region 3. The advancement is carried out, for example, by way of an individual drive 4, which drives a spindle 6 through a gearing 5.

The forming tools 9, which are driven by drive 8, are mechanically directly connected through a Maltese cross type gearing 7 with the workpiece holder 2. The intermittent rotation about the axis z of the workpiece holder 2 is thereby directly coupled or synchronized with the movement of the forming tools 9 according to the design of the gear ratio and the Maltese cross type gearing 7. On the basis of this design, a defined profile can now be machined into the surface of the workpiece 1 by the forming tools 9.

With this arrangement, respectively only one profile can be produced having a specific profile or tooth number. For a different tooth number, the gear ratio between the

drive 8 and the workpiece holder 2 must be adjusted, which can only be carried out by exchange of the corresponding gears or gearing parts. Such an exchange is time consuming and very cost intensive.

A longitudinal section through a device in accordance with the invention is schematically illustrated in Figure 2.

The construction and drive mechanism of the machining region 3 corresponds to the known construction as illustrated in Figure 1. The drive 8 is advantageously connected with the forming tools 9 by way of a mechanical gearing 10.

However, the workpiece holder 2 with the workpiece 1 now has its own drive 11. The advancement of the workpiece 1 also advantageously occurs through a separate drive 4 with gearing 5 and spindle 6, whereby the drive 11 is also advanced together with the workpiece 1 or the workpiece holder 2.

The synchronization between the intermittent rotational movement of the workpiece holder 2 and thereby the workpiece 1 and the forming tools 9 or the drive 8 is carried out electronically in accordance with the invention by way of a control. The drive 8 as well as the drive 11 thereby preferably have corresponding position sensors.

The great advantage of the electronic synchronization resides on the one hand in that the control can be quickly and individually and easily adjusted according to the settings of the profile partitioning without the need for intervention in the impact rolling machine. On the other hand, movement sequences, which means special rotation patterns of workpiece 1, can also be achieved thereby, which cannot be realized or only at large operating expense with a mechanical gearing, but which are necessary, for example, for the impact rolling of helical toothings. Furthermore, the use of tools provided with a recallable coding or programming allows for an especially easy adjustment or programming of the control of the machine so that a manual adjustment is practically obviated.

Figure 3 schematically illustrates a front view of a workpiece 1 engaged by a machining tool in the form of a profile wheel 12. The profile wheel 12 is here illustrated at its actual maximal penetration depth into the surface of the workpiece 1. According to the profile of the profile wheel 12, a profiling of the workpiece surface is achieved and in particular at a spacing t which is defined as profile division.

This region is fully illustrated in longitudinal section in Figure 4, from which it is apparent that the profile wheel 12 is guided along a circular orbit, whereby the circle 13 represents the orbit of the outermost regions of the profile wheel 12. The profile wheel is illustrated on the one hand at its exit position 12' where it just leaves the surface of the workpiece 1, as well as in the approach position 12'' in which the forming action on the workpiece 1 is commenced and the profile wheel enters the region of the profile just formed. The workpiece 1 must remain still between these two positions so that the desired profile shape can be exactly achieved, while the workpiece 1 must be rotated by the profile division t during the following revolution of the profile wheel 12 about its orbit in order to achieve a profiling over the whole circumference. This standstill phase can be achieved in accordance with the invention exactly by the separate drive and the electronic synchronization and easily adapted to the number of teeth to be generated, especially with respect to the location and duration of the workpiece standstill.

A high production rate can be achieved through high rotation speeds especially during the manufacture of such profiles in hollow cylindrical sheet steel parts and the adjustments critical for the profile geometry can be carried out quickly and easily by way of the corresponding control. These adjustments are preferably carried out automatically with the use of chip coded tools and, for example, activate without manual intervention a program already contained in the control.

With the conventional devices and especially in such hollow parts, differently high pressure is generated by the profile wheels 12 on the flanks of the profiling by the rotation and advancement along the longitudinal axis of the workpiece. In the device in accordance with the invention with electronic synchronization and independent rotation drive, this effect can be practically eliminated by a corresponding compensation rotation about the longitudinal axis of the workpiece 1. With mechanical solutions, this could generally only be carried out at high expense and not completely.

A helical toothing can also be realized with the impact rolling tools, for example, by way of the individual controllability of the intermittent rotation of the workpiece.

Furthermore, the construction in accordance with the invention with electronically coupled drive also allows the use of the same machine for pressure rolling with pressure wheels whereby an intermittent rotation of the workpiece is not necessary but the latter must be rotatably driven with a predetermined, generally very high constant rotation

speed. The retooling of the mechanical gearing necessary with the conventional devices is thereby obviated, since it can also be easily adjusted and carried out electronically by way of the control. This pressure rolling process renders it possible to first preform from a disk a thin-walled hollow part on a pressure mandrel and to then subsequently tooth it on the same pressure mandrel in the same process step.